Multisim Circuit Files to Accompany

Digital Fundamentals: A Systems Approach, 1st Edition
by Tom Floyd

Notes and Clarifications

Effective 05 Dec 11

1.   Overview

Multisim Circuit Files to Accompany <u>Digital Fundamentals: A Systems Approach, 1st Edition</u> (DFASA) by Tom Floyd consists of student and instructor files. The student files consist of circuit files only. The instructor files consist both of the student circuit files and solution files that include circuit measurements and results.
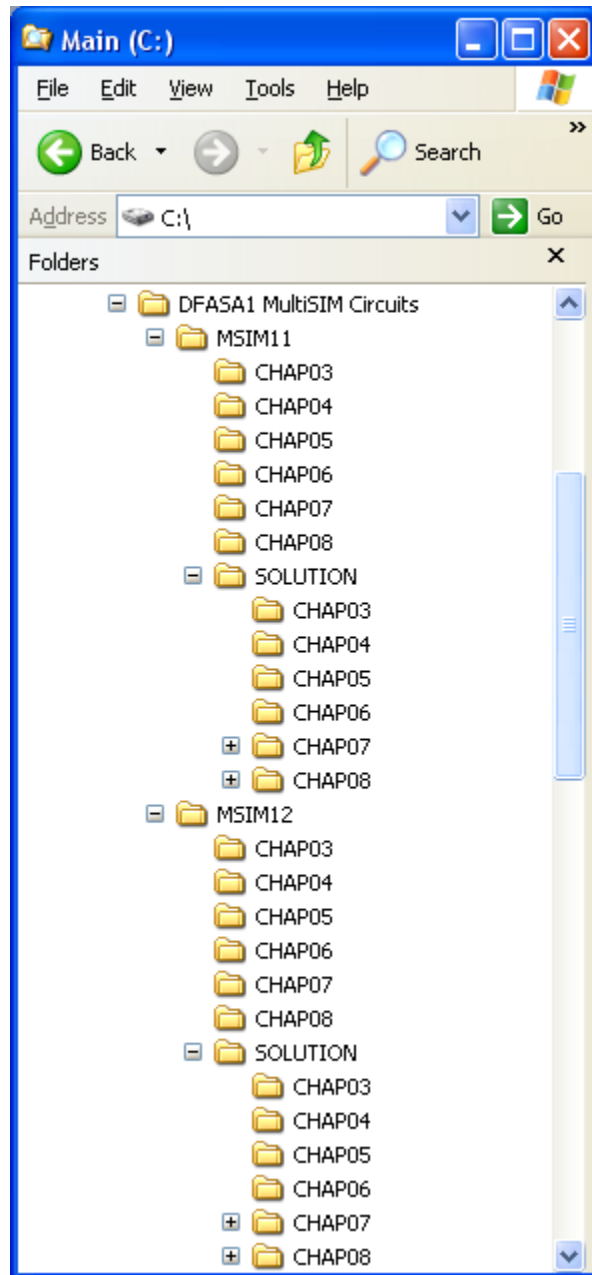
2.   Circuit Files

2.1.   Folder Organization

Student files are organized in the following folders shown in Figure 1:
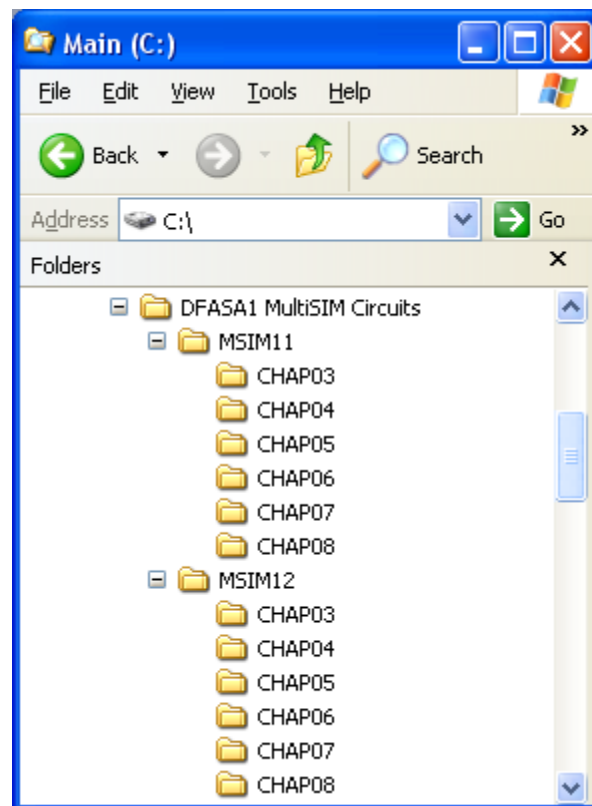
Figure 1: Student Circuit Files Folder Organization

Figure 2: Instructor Circuit Files Folder Organization

2.2.   Circuit File Organization

Each circuit set contains files in both Multisim 11 and Multisim 12 formats. All Multisim 11 circuit files are contained in the chapter subfolders in the MSIM11 folder and have a .MS11 file extension. All Multisim 12 circuits are contained in the chapter subfolders in the MSIM12 folder and have a .MS12 file extension. Multisim 11 will work only with the .MS11 files. Multisim 12 will work with both .MS11 and .MS12 files, although the software will automatically convert the .MS11 files to .MS12 format.

2.3.   Chapter Subfolders

For convenience, the circuit files are contained in chapter subfolders. The names of the chapter subfolders correspond to the chapter number of Digital Fundamentals: A Systems Approach in which the circuits are referenced. For example, Chapter 3

circuits are contained in the CHAP03 subfolder, Chapter 4 circuits in CHAP04, and so forth.

2.4. Multisim 11 and Multisim 12 Circuit Files

All circuit files are provided in both Multisim 11 and Multisim12 format.

3. Circuit Files

The Multisim circuit files consist of two basic types. The first type consists of simulation circuits. The second type consists of troubleshooting circuits.

3.1. Simulation Circuits

Simulation circuits are circuits intended to demonstrate or illustrate some principle of digital circuit theory. These circuits typically have input and output devices already connected and require the student to run the simulation, activate the inputs when necessary, and observe the outputs for the given inputs.

3.2. Evaluation and Troubleshooting Circuits

Evalution and troubleshooting circuits require the student to select some means of applying inputs to and observing outputs from the circuit.

4. Circuit File Simulation Tips and Techniques

This section contains some guidelines for using Multisim to simulate the circuits provided for Digital Fundamentals: A Systems Approach, 1st Edition. It is not and is not intended to be a general tutorial for using Multisim. For more information on using Multisim the student and instructor should refer to the Multisim User's Manual and online help.

4.1. Simulation Options

Multisim provides a number of options for supplying inputs and monitoring outputs in the Multisim circuits. While there is no "right" or "wrong" way to simulate a circuit, the purpose of the simulation and the nature of the circuit often favor a particular approach.

For simulating static operation of digital circuits, such as demonstrating or verifying the operation of logic gates or purely combinational logic circuits, switches and probes or LEDs are the most typical simulation approach. This will be true in general for when static, or steady-state, inputs and outputs are sufficient to verify the circuit. Thisapproach is also useful when the expected number of simulations or inputs and outputs is small. In real-world environments this approach is best-suited to prototyping or pre- production circuit evaluation.

For simulating dynamic operation of digital circuits, such as demonstrating or verifying the operation of flip-flops or sequential logic circuit such devices as word generators, signal generators, logic analyzers, oscilloscope, and other time-varying devices are used. In theory switches, probes, and LEDs can be used but are less practical as the changes in circuit states, rather than the states themselves, are typically of interest. This is especially true if a large number of inputs and outputs are involved or a large number of simulations are expected. In real-world environments this approach is taken for production circuit testing in which automation is preferred to reduce the time and cost of testing many units.

5. Circuit Faults

Multisim versions 10.1 and later do not support faults in digital components. Consequently, the circuits that relate to end-of-chapter problems have been changed from previous editions. These circuits require the student either

1) to predict the effects that a specific fault would have on the circuit, or
2) to predict the fault that would affect the circuit in a specific way.

The student then verifies the prediction by inserting the fault into the circuit and observing the results. Each chapter folder contains a worksheet on which the student can record the predicted and actual effects for the faults.

5.1.   Faults in Multisim

Students must take some precautions when inserting faults into Multisim circuits. Although circuit faults in Multisim will not create actual safety hazards as in real circuits, some faults can cause program errors that will cause Multisim to prematurely terminate a simulation or even shut down entirely. In particular, students should ensure that a fault does not short out a voltage supply or short an output directly to voltage or ground.

5.2.   Inserting Shorts

To ensure that a short does not create problems, small-value current limiting or isolation resistors can be used. Current limiting resistors are used to ensure that a fault does not short out a voltage supply. Isolation resistors are used to ensure that an output is not shorted directly to voltage or ground.
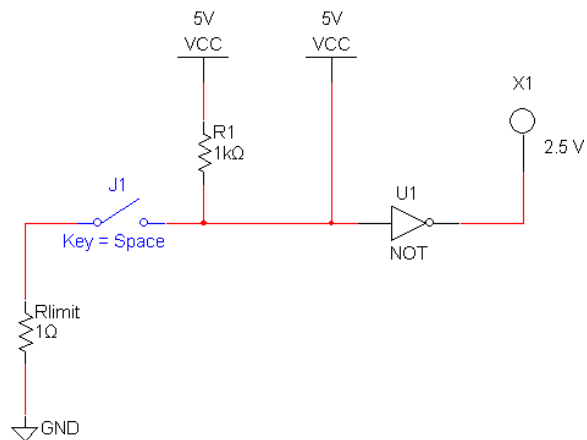

Figure 3: Current Limiting Resistor

Figure 4 shows a current limiting resistor used to prevent any problems with shorting the input of U_1 to V_{CC}. Although there is no problem as long as J_1 is open, closing J_1 would short out V_{CC} without R_{limit} in series with J_1 and ground.
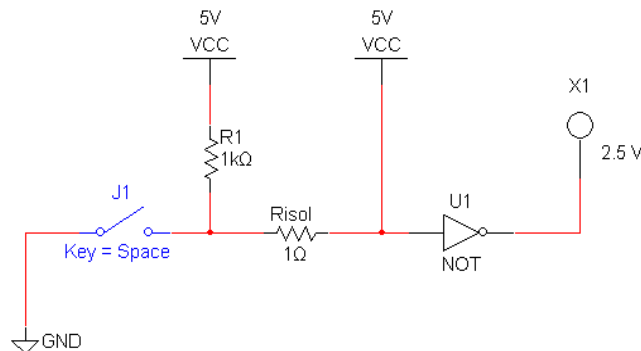
Figure 4: Isolation Resistor on Input

Figure 5 shows another method that safely shorts the input of U_2 to V_{CC}. In this case, the faulted circuit contains a small isolation resistor between the input of U_1 and J_1. Isolation

resistors should be used whenever a fault could short the output of a device to V_{CC} or ground. Figure 5 shows an example of this.
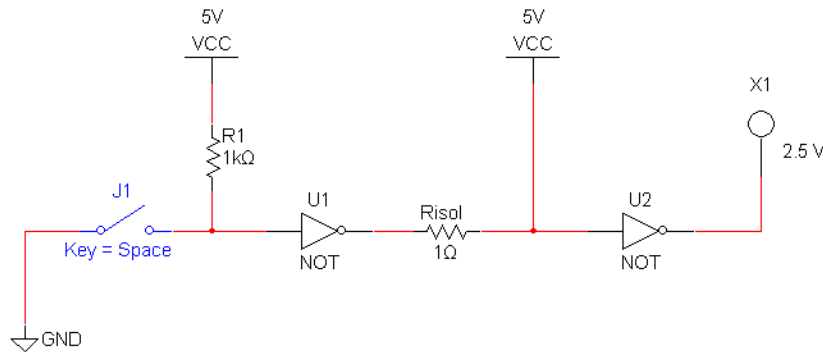
Figure 5: Isolation Resistor on Output

In Figure 5, shorting the input of U_2 directly to V_{CC} without R_{isol} would probably cause a simulation error, as this would also short the output of U_1 directly to V_{CC}. Because the output of U_1 normally connects directly to the input of U_2, this circuit can be used to simulate either the output of U_1 or the input of U_2 shorting to V_{CC}.

5.3. Inserting Opens

There are two ways to insert an open in a circuit. One way is simply to delete the wire between two points to create the open. A second way is to insert a very large (1 GΩ) resistor between the two points to simulate an open.

5.4. Simulating Leakages

To simulate a current leakage through a component, simply connect a resistor with an appropriate value in parallel with the component.

6. Circuit File Simulating Tips and Techniques

This section contains some guidelines for using Multisim to simulate the circuits provided for Digital Fundamentals: A Systems Approach, 1st Edition (DFASA). It is not and is not intended to be a general tutorial for using Multisim. For more information on using Multisim the student and instructor are referred to the Multisim User's Manual and the online help.

6.1. Multisim 11 vs. Earlier Versions of Multisim

The user with access to both Multisim 11 and earlier versions of Multisim may notice that circuits that simulate without problems under earlier Multisim versions may not simulate correctly or in the same way when converted to Multisim 11 format. There are several things that the user may try to correct the problem.

1) Install the latest upgrade or patch for your version of Multisim. These may be found at http://www.ni.com on the World Wide Web. Typically patches for only the latest version of Multisim are available.

2) If Option 1 does not work or is not available, adding signal probes to nodes along of the signal paths can sometimes get the simulation to work as expected.

3) Occasionally the simulation will not run because the circuit has not been properly initialized. If this is the case a dialog box will appear advising the user to try running the simulation again.

If none of the above suggestions work it may be necessary to rebuild the circuit from scratch using components from your version of Multisim or to contact Technical Support at National Instruments. All the solution circuits provided have been tested to ensure that they simulate as expected. An AMD Phenom 9500 Quad Core 2.2 GHz system running Windows XP Professional SP3 with 4 GB of RAM was used to test the circuits.

6.2.   Metastability

In the ideal case, all digital circuit nodes either will be at a logic 1 or 0 or rapidly transitioning from one to the other. In the real world this is not always the case. There are times when a logic circuit will enter a "metastable" state in which the logic levels are not valid and yet the circuit can remain in this state indefinitely. This is typically due to a violation of the timing specifications (such as setup and hold times) or operating conditions (such as asserting and then simultaneously negating the PRESET and CLEAR inputs of a flip-flop) for the circuit components. In the DFASA circuits files all solutions have been tested to ensure that metastability can be avoided, although the possibility cannot be completely eliminated.

6.3.   Initial conditions

In ideal circuit simulations the initial state can be arbitrarily determined. This is not so in practical circuits. For bistable components (flip-flops) in particular, the exact starting state is indeterminate unless a circuit is added to force the device to a known state following power-up. In Multisim this circuitry is sometimes required. For a number of flip-flop circuits, for example, an RC delay has been added to one of the synchronous inputs to force the flip-flop to a known power-up state during the simulation (typically the RESET state). If students have issues in getting a sequential circuit to start up, forcing a known initial state is suggested.

6.4. Simulation problems

From time to time a simulation will stall or halt unexpectedly, or report a convergence error. All circuits for DF8 have been tested to ensure that no errors should be generated, although there are some situations using the word generator in which the simulation may halt when BURST mode is used. Typically clicking on the BURST button will resume the simulation. If a convergence or other error occurs, one solution may be to configure the instrument analysis defaults (under the "Simulate" menu) so that the maximum time step is set to 0.001 seconds and initial conditions are "Set to zero".

6.5. Missing Circuit Files

All circuits referenced in DFASA are available in both Multisim 11 and Multisim 12. There should be no missing circuit files.

6.6. Simulation Options

Multisim offers a number of options for supplying inputs and monitoring outputs in circuits. While there is no "right" or "wrong" way to simulate a circuit, the purpose of the simulation and the nature of the circuit often favor a particular approach. For circuits in which the circuit states are important, switches and LEDs are useful for applying inputs and outputs. For circuits in which state changes are important dynamic devices such as the word generator and logic analyzer are better choices for applying inputs and observing outputs. For circuits in which you desire to know some precise value of a digital signal value (such as the period of a pulse waveform or the time between signals) an oscilloscope is preferred. For circuits in which only changes in logic levels or the relative sequence in which events occur a logic analyzer is a more suitable choice.